RESEARCH PROPOSAL

Design and Implementation of a Predictive Data Mining Technique for Depression Prognosis

For Registration to the Degree of

Doctor of Philosophy

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1. Introduction

Data mining is one of the promising research fields for its attempt to predict and analyze data from different perceptions and summarize it into significant information in order to identify hidden patterns from a huge dataset. This technique is a game changer in the world of statistical analysis and business. Data Mining has been used in many different sectors of business, to both, predict and discover trends. It is a proactive solution for businesses looking to gain a competitive edge. It has found its use in almost all the sectors such as education, health care, financial services, banks, shops. It helps in predicting future aspects thereby help to take decisions for future easily.

Healthcare organizations are exploiting data mining technologies for improvising their clinical and business processes. Data mining holds great potential to improve health systems. It uses data and analytics to identify best practices that improve care and reduce costs. The techniques of data mining are widely being used for the prediction of various diseases such as heart diseases, diabetes, and cancer to name a few. These facilitate doctors in diagnosing and make their clinical decisions. One of the major health problems the world faces is depression. As per World Health Organization, depression is the leading cause of disability worldwide and is a major contributor to the overall global burden of disease (WHO, 2018). In the diagnosis of depression where the uncertainty plays a major role, an intelligent system can provide high levels of accuracy than the traditional methods. Prediction of depression is complicated in nature due to its subjective symptoms. The combination of these as well as many more factors makes depression a major global health concern. The scarcity of well trained and experienced professionals in many regions of the world makes the condition even worse. Thus, it is important and necessary to apply data mining techniques to help counter these problems as well as help in prediction of depression.

1.1 Depression

Depression is one of the most common problems that affect a large population today and is noticeable in any age group. It is estimated by WHO that nearly 676 million people in the world (approx 1 in 10 people) suffer from depression and by 2030, it will be the leading cause of disease burden globally (Suhara et al. (2017)). Depression often precedes and may cause directly

or indirectly many chronic conditions such as high blood pressure, diabetes, insomnia. Serious depression in a person can affect the family life and destroy the life of the affected person if not treated on time. Depression is associated with loss of appetite, headaches, body pain, mood disorders, irritability, frustration, unnecessary anxiety, loss of self esteem, fear of death, fatigue, inability to experience pleasure, feeling of guilt etc.

The causes of depression are as follows (D'monte, 2015):

- Abuse- Any kind of past physical, sexual or emotional abuse can increase the chances of depression in later life.
- Conflict- A person having conflict with his/her partner, parents, children or any family member is vulnerable to depression.
- Death or loss- Losing a family member or a loved one may lead to depression.
- Genetics- A family history of depression can increase the risk of depression.
- Stress and Frustration- Stress which can be either due to losing of a job, getting divorced, losing of money in any way and frustration of not being able to face the challenges of life and not being able to enjoy life, getting jealous of others etc. may gradually lead to depression.
- Social Isolation- A person who remains isolated either by choice or is forced out of a family due to some reasons is most likely to suffer from depression in later stages of life
- Serious Illness- A person when suffering from some serious illness is also vulnerable to get clutched by the dangerous symptoms of depression along with the illness.

The symptoms of depression are as follows (Morrison, (2017)):

- Changes in Appetite- At times it causes weight loss and at times weight gain; loss of appetite or increased appetite.
- Sleep Disturbances- Lack or loss of proper sleep; at times increased sleeping time or difficulty in having a sound sleep
- Loss of Interest- A person loses interest in almost everything whether it be meeting friends or going to job or enjoying with family members.
- Difficulty in concentration, thinking or making decisions- A person fails to take proper decisions, cannot concentrate on their work, and keep on thinking unnecessarily over pity matters which results in headache, weakness, stomach problems and many more.

Depression is a critical public health problem characterized by persistent low mood that is accompanied by low self esteem and loss of interest or pleasure in normally enjoyable activities (Kim, 2015). Depressed people cannot control their emotions and the symptoms last for a long time. If left untreated it can lead to serious fatalities. Therefore such problem can be addressed by the application of data mining techniques that can cater our needs to predict depression.

1.2 Data Mining

The abundance of data, has led to a condition of data rich but information poor. The fast growing, tremendous amount of data are collected and stored in large and numerous data repositories. As a result such data collected and stored become "Data Tombs"- Data Archives that are seldom visited. Data mining tools perform data analysis and may uncover important data patterns, contributing greatly to business strategies, knowledge bases, and scientific and medical research. The widening gap between data and information leads to the requirement for a systematic development of data mining tools that will turn data tombs into "Golden Nuggets" of knowledge.

Data Mining refers to extracting or "mining" knowledge from large amounts of data (Concepts, 2006). It is also known as discovery of knowledge from data or knowledge discovery in databases. Using data mining, previously unknown, comprehensible and actionable information from large databases are extracted which is used to make important business decisions.

Data mining is an iterative process that typically involves the following phases (Ahmed, 2012):

1) Problem definition:

- A data mining project starts with the understanding of the business problem. Data mining experts, business experts, and domain experts work closely together to achieve the project objectives. The project objective is then formulated into a data mining problem definition.

2) Data exploration:

- Domain experts understand the meaning of the metadata. They collect, describe, and explore the data. They also identify quality problems of the data.

- In the data exploration phase, traditional data analysis tools, for example, statistics are used to explore the data.
- Exploration techniques include calculating the minimum and maximum values, calculating mean and standard deviations and looking at the distribution of the data.

3) Data preparation

- Domain experts build the data model for the modeling process. They collect, cleanse, and format the data because some of the mining functions accept data only in a certain format. New derived attributes are also created.
- In the data preparation phase, data is improved multiple times irrespective of order. Data is prepared for the modeling tool by selecting tables, records, and attributes which are typical tasks in this phase. The meaning of the data is not changed.

4) Modeling

- In this phase, data mining experts select and apply various mining functions. Different mining functions for the same type of data mining problem can be used. Some of the mining functions require specific data types so the data mining experts must assess each model.
- In the modeling phase, a frequent exchange with the domain experts from the data preparation phase is required.
- The modeling phase and the evaluation phase are coupled and are repeated several times to change parameters until optimal values are achieved. When the final modeling phase is completed, a model of high quality is built.

5) Evaluation

- In this phase, the prepared model is evaluated in this phase. If the model does not satisfy the expectations, return to the modeling phase and rebuild the model by changing its parameters until optimal values are achieved. When data mining experts are finally satisfied with the model, they extract business explanations and evaluate the following questions:
  - Does the model achieve the business objective?
  - Have all business issues been considered?
- At the end of the evaluation phase, the data mining experts decide how to use data mining results.

6) Deployment

- Data mining experts use the mining results by exporting the results into database tables or into other applications, for example, spreadsheets.

Figure 1 shows the phases of the Cross Industry Standard Process for data mining (CRISP DM) process model.

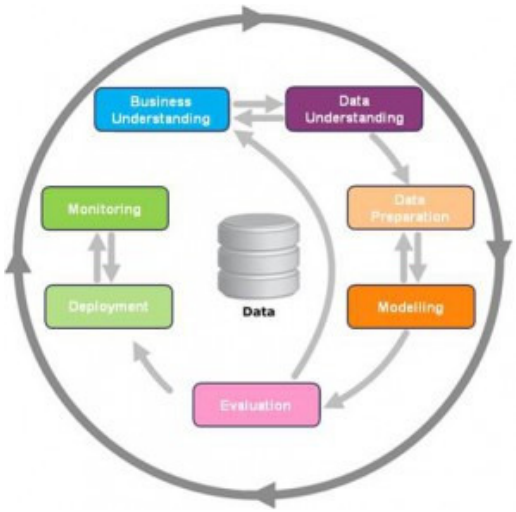


Figure 1: The CRISP DM process model (Pradhan, 2014)

One of the most important tasks in the process of data mining is, to select the correct data mining technique. It has to be chosen based on the type of business and the type of problem the business faces. A generalized approach should be used to improve the accuracy and cost effectiveness of using data mining techniques. Various data mining techniques have been developed. The classification of data mining techniques is shown in Figure 2.

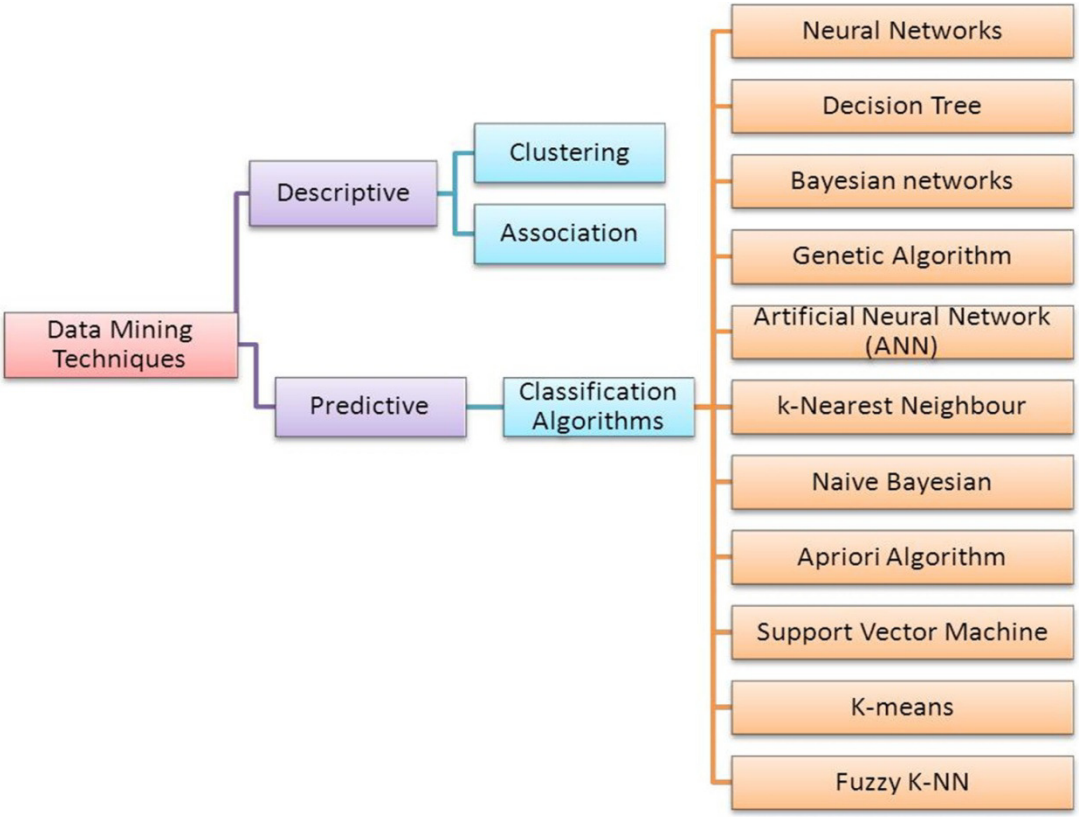


Figure 2: Data Mining Techniques (Raval, 2012)

The techniques of data mining can be divided into the following two categories-

- **Descriptive Data Mining**

Includes all the data aggregation methods and techniques that provide an insight into past data. It analyzes all past data and provides answers to the questions such as "What has happened till date?"

- **Predictive Data Mining**

Encompasses a variety of statistical techniques such as modeling, machine learning, that analyze current and historical facts to make predictions about future events. It provides answers to the questions such as "What can happen?" in future. Predictive data mining includes a number of classification algorithms such as artificial neural networks, decision trees, support vector machines, K-means, fuzzy logic, Bayesian classifiers, genetic algorithms etc that can be used for the prediction of future trends in data and help in decision making.

Out of the various data mining techniques under predictive mining methods, the aim of our study is to focus on the use of a subset of these techniques such as ANN, Fuzzy Logic, K-means for the prediction of depression in patients. The purpose of using ANN, Fuzzy logic for depression classification is because the working concepts of ANN are based on statistics due to which it assures correct classification of depression, moreover ANN can classify depression even if there is a slight change in collected data and can be trained with minimum patterns (Bhuvana (2014); Sau and Bhakta (2017)). Medical data related to depression is characterized by inescapable uncertainty (Gursel, 2016). Fuzzy Logic is a term that is associated with uncertainty, vagueness, fuzziness, having common feature as not being clear enough to be processed by hard computing techniques. Fuzzy logic deals with approximate values instead of certain values so commonly used for prediction of depression.

1.3 Application of Data Mining in Depression Prognosis

Prediction in data mining is an approach that helps to identify events which have not yet occurred. This approach is getting more and more interest for the healthcare providers in the medical domain since it helps to prevent further chronic problems and could lead to a decision about prognosis (Banaee et al. (2013)). This approach is also known as supervised learning model. For the prediction of data behavior it includes the steps: feature extraction, training and testing. In the proposed study, we aim to design and implement data mining algorithm for the prediction of depression. The patterns that emerge from data mining will not only improve understanding of this disease, but can give new insights into prediction. This approach balances the fact that no two cases of mental illness are the same as all patients are individuals and different.

2. Review of Literature

A review of literature is presented that depicts different data mining techniques used for the prediction of depression and its different states in different age groups of people.

Sau and Bhakta (2017) stressed that, depression is one of the most important causes of mortality and morbidity among the Geriatric population. As the brain experiences aging it become more vulnerable to depression. They studied various socio-demographic factors and morbidity attributes to predict depression among geriatric population using Artificial Neural Network.

Multilayer Perceptron (MLP), a feed forward ANN model was built in WEKA 3.8.0 for classification with input variables i.e., age, gender (Male/Female), living spouse (Yes/No), type of family (Nuclear/Joint), Literacy (Literate/Illiterate), occupational status (presently working/ presently not working), personal income (Yes/No), and substance abuse (Yes/No), hearing problem (Yes/No), visual problem (Yes/No), mobility problem (Yes/No) and sleeping problem (Yes/No). The ANN model was designed with seven interconnected neurons in one hidden layer. Primary data was collected by interviewing 105 elderly at their homes who belonged to Service Area of Urban Health and Training Centre, Kolkata. They were selected by simple random sampling technique without replacement. This data was used as a training data set for data mining in Weka. Then, the predictive model was build using ANN as a classifier in the Weka. Output was classified as - depressed and non-depressed. ANN model was trained and tested on the primary data set with 10-fold cross validation method. Out of 105 instances, 102 were correctly classified with accuracy precision 97.2%.It was concluded that predictions can be made within seconds using socio-demographic and morbidity factors. The study was carried out in a limited area which can be extended to different parts of the country for further generalization. This will help to build a robust prediction system in future as extending research to different parts can help to extract common features or symptoms of depression and lead to better results.

Suhara et al. (2017) stated depression as a prevailing issue in people's lives which generally go un-noticed. They dealt with the challenge to forecast severely depressed moods based on self reported histories of 2382 self declared depressed people. They developed a smart phone application for collecting data. During data collection moods of the persons in different time slots, their action types and sleeping time were also recorded. PHQ-9 and GAD-7 were used for data collection. Later on EMA- Ecological Momentary Assessment was used. It was found that long term historical information of a user improved the accuracy in forecasting depressed mood. A recurrent neural network (RNN) algorithm was developed that incorporated categorical embedding layers (dependencies from previous states) for forecasting depression. Experiments have been conducted and results showed RNN with hidden LSTM (Long Short term memory units) are powerful models from learning from sequential data and it outperformed SVM (Support Vector Machines) by generating results with higher accuracy.

Chattopadhya (2017) considered the severity of real world depression cases and implemented a fuzzy neural hybrid model for the diagnosis of the same. Principal Component Analysis, a method used to extract hidden features from multidimensional data was used here. It helped to extract the significant features by reducing the number of symptoms. In this study, fourteen symptoms of depression have been considered which denotes independent factors. Few of them were- feeling sad, weight loss, insomnia etc. In their study, data of total 302 adult 'psychotic depression' cases have been collected from two hospital sources in India. Data has been finally normalized using max-min normalization technique. An input vector matrix was created with significant symptoms and then a fuzzy neural hybrid model was developed and tuned with back-propagation neural network algorithm. He concluded that the developed hybrid model was able to automate the diagnosis process with 95.5% accuracy. Expert tool development could be carried out in future where the model would be incorporated with inbuilt knowledge base and no repetitive training will be required.

Bhakta and Sau (2016) studied depression among elderly population which is one of the emerging problems of public health. They used Weka for prediction based on machine learning classifiers. In this study five machine learning classifiers - Bayes Net, Logistic, Multilayer Perceptron, SMO (Sequential Minimal Optimization) and Decision Table were used. These classifiers were compared with respect to three different test options using training and testing set, cross- validation and percentage split. The training data set was loaded in WEKA and then filters were applied on data set for optimized result. After pre-processing, result was fed into the classifiers and corresponding test options were selected. Prediction output format was chosen to view the result in human readable format. After all these setups, prediction was started and result was collected in a text file. From the study, it was clear that SMO was more accurate and précised model for prediction of depression among senior citizens. Future work can include other learning methods for better accuracy.

Bhuvana et al. (2015) made use of two ANN algorithms: Back Propagation Algorithm (BPA) and Radial Basis Function (RBF) for categorizing and identifying the type of depression. 21 inputs were fed to the algorithm. A multiple choice questionnaire Hamilton depression rating scale was used to collect information from the affected patients. The scale provides an indication of depression and as a guide to evaluate recovery. Depression data of 1800 patients based on

Hamilton rating scale were collected through oral discussion. The information not being precise was presented into the input layer of ANN algorithm and processed with stored weights. The outputs received from the output layer of the ANN were used to retrieve the information from the database. The information provided by the patients provided complete information on the basis of which the doctors could suggest remedies. Here, the Radial Basis Function (RBF) Neural Network consisted of an input layer, an output layer and a single hidden layer. A distance measure is used to associate the inputs to outputs. RBF is capable of performing approximations with an additional advantage of not being involved in repeated training. The future work can include the correlation of collected data with the commercial psychological database. The Psychology Database combines high impact full text from leading psychology and psychosomatic publications, with diverse sources of content including dissertations and training videos which can provide better accuracy in results.

Mukhurjee et al. (2014) stated that depression is a serious disease that affects a large fraction of the global population. The diagnosis of depression faces a problem due to uncertainty of widely varying symptoms. An attempt was made to model a three layered fully connected neural network taking into account ten common symptoms namely - feeling sad, loss of pleasure, weight loss, insomnia, hypersomnia, loss of appetite, psychomotor agitation were considered, by consultation with 3 senior psychiatrists. The grade of each symptom and the corresponding probability of depression were assigned [0,1]. The model consisted of 3 layers: the input layer, the hidden layer and the output layer. There were 10 neurons in the input layer corresponding to the 10 symptom units. The hidden layer had variable number of neurons ranging between 3 and 15. The output layer has only neuron that gives the final output as degree of depression. The weight sets [v] and [w] connect the outputs of input layer to outputs of hidden layer and the outputs of hidden layer to the inputs of output layer. In this case, weight sets [v] and [w] are finely tuned to optimize the system with the help of a back-propagation algorithm. A radial basis function neural network was built in the second approach that used linear transfer functions and a radial basis function as its transfer function. The future work can include: obtaining greater quantities of sample data, correlation and standardization of the data sets.

Chattopadhya et al. (2008) made an attempt to develop fuzzy logic based expert system which may be able to reason like doctors for screening adult psychosis. Among several techniques of

fuzzy classifier (FC)-design, clustering to classifier technique (CCT) has been adopted. The key objective was to develop a classifier system that is able to determine the chance of occurrence of adult psychoses.

Yu et al. (2008) carried out a study with the purpose to apply fuzzy theory on health care with depression as a special case. They performed comparative study of the accuracy of -possibility based (fuzzy c-means) and probability based classification (k-means) to classify the severity of depression. The diagnose criteria of depression disorder included 9 symptoms (mood, interests, eating, sleep, motor-activity, fatigue, self-worth, concentration and death). Beck Depression Inventory (BDI)-2 was adopted as the instrument that was specifically developed to address all 9 criteria for a major depressive episode. Participants were asked to circle the number (0 to 3) associated with the item that best described how they had felt over the past two weeks. Percentages were assigned on the chosen alternatives. The results of fuzzy scoring were utilized in clustering analysis. The response pattern in self reported instrument was analyzed via FCM, Wald's method and k-means. To compare FCM with other crisp clustering methods the results of FCM were modified in two ways. Fuzzy based FCM was found to yield stronger associations between original and classified groups than crisp based clustering. Moreover it was proved to be more accurate.

The literature review has provided an insight into some of the commonly implemented data mining techniques used to predict depression such as ANN, Fuzzy Logic, Backpropagation and K-means. These studies show that there is enough scope in the design and development of predictive techniques for the prediction of depression as there are certain limitations with the works reported in the past. These include uncertainty related to data collection from self reported histories due to lack of knowledge, data collection which is confined to limited areas, as well as requirement of repetitive training of networks. The further improvements can include, collection of data from wider areas, collaboration of collected data with psychological databases for greater accuracy, building an expert tool with inbuilt knowledge base.

3. MOTIVATION

Depression has affected 2-3% of the global population and increasing day by day due to stress which is quite alarming. In India, one in every four elderly individuals is suffering from depression (Bhakta, 2016) .When depression lasts for more than two weeks; it becomes a serious issue and needs to be treated at the earliest. If the diagnosis criteria are not observable, the signs of depression may go unnoticed, which results in higher demand for the prediction of depression in advance automatically.

There has been a very limited research work in this field, due to the uncertainty related to the data. There are no fixed symptoms of depression; amalgamation of more than one psychotic illness in a patient makes the situation even more complex. Depression has been neglected due to unpredictable symptoms and treatments based on speculations. Moreover collection of data related to depression cases is quite difficult as it is against the ethics of the doctors to disclose information related to the mental health conditions of their patients. Such are the challenges being faced by researchers of this field

Depressed people can feel sad, anxious, empty, hopeless, worried, helpless, worthless, guilty, alone, irritable, hurt or restless. They also lose interest in activities that were once pleasurable, experience loss of appetite or overeating, oversleeping or insomnia, weakness, digestive problems, headaches and some serious issues may also lead to people harming themselves or even as fatal as committing suicides.

As a result it becomes very necessary for a quick and immediate automated prediction and diagnosis system for a patient. This can be achieved only with the help of an intelligent data mining technique for the vast amount of data related to depression cases. Such data mining intelligent algorithms can better classify the collected data and generate interesting patterns which can help in the better understanding of the disease; moreover the patients will be able to receive higher personalized treatments. ANN, Back propagation and Fuzzy logic have been used so far for the prediction and diagnosis of Depression. The alarming increase in the rates of depression cases however calls for the development and implementation of improvised prediction techniques that achieve the required amount of satisfaction and standardization.

4. Objectives

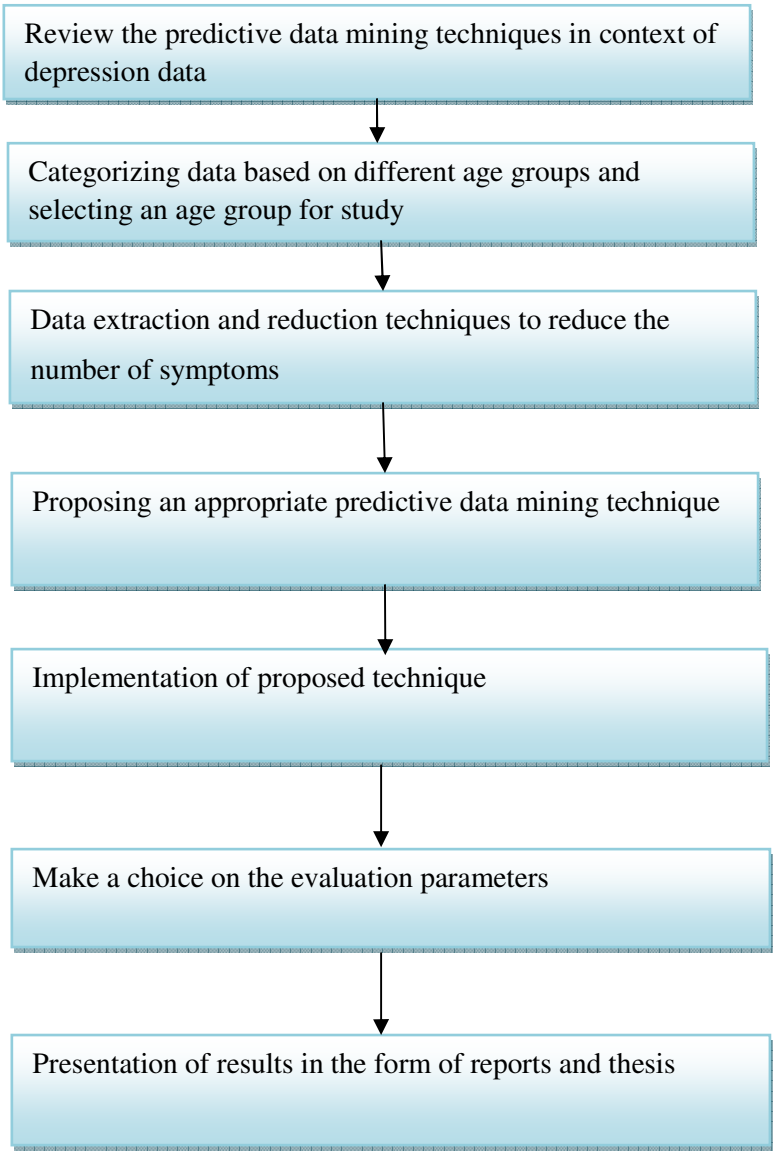
Based on the review of the relevant research studies, the main objectives of the proposed work are summarized as follows:

1. To study and systematically review the classification and prediction data mining techniques in the context of depression problem.
2. To prepare a dataset while identifying the suitable age group for study.
3. To identify the parameters/symptoms significant for the prediction of depression.
4. To propose a suitable prediction technique based on availability of data and significant symptoms extracted for the prediction of depression.
5. To implement proposed technique for prediction of depression
6. To evaluate the proposed technique and cross validate the model.

5. Methodology

1. Review the predictive data mining techniques in context of depression data by keeping track of the latest research. This would be done by studying related articles published in journals.
2. Prepare a dataset and categorize based on age groups while identifying suitable age group
3. Normalization and preprocessing of data which includes exploring the different features and symptoms of depression and extraction of significant features using appropriate data extraction and reduction techniques to reduce the number of symptoms.
4. Proposing an appropriate predictive data mining technique based on data collected and features extracted to predict depression.
5. Implementation of proposed technique.
6. Making a choice of the evaluation parameters.
7. Evaluate the proposed technique to test if expected results are met.
8. Presentation of results in the form of research papers and thesis report.

Work Flow

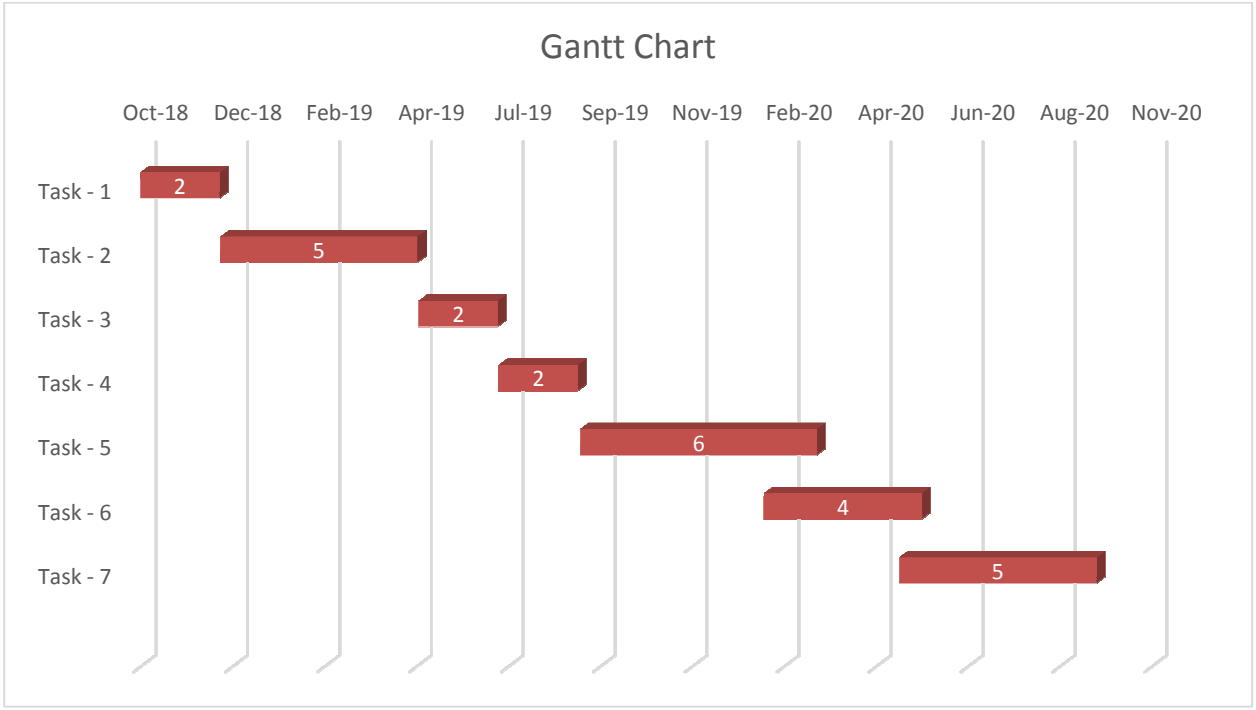

Review the predictive data mining techniques in context of depression data
Categorizing data based on different age groups and selecting an age group for study
Data extraction and reduction techniques to reduce the number of symptoms
Proposing an appropriate predictive data mining technique
Implementation of proposed technique
Make a choice on the evaluation parameters
Presentation of results in the form of reports and thesis

6. Plan of Work

The work plan indicated the projected timing of the next milestone in the research. We have divided our research work in the following phases which are as follows:

Phase No.	Phase Description	Approximate Duration (in months)
1	Review the predictive data mining techniques in context of depression data	**2-3 Months**
2	Prepare a dataset and categorize based on age groups while identifying suitable age group.	**4-5 Months**
3	Normalization and preprocessing of data	**2-3 Months**
4.	Proposing an appropriate predictive data mining technique based on data collected and features extracted to predict depression	**2-3 Months**
5	Implementation of proposed technique	**5-6 Months**
6	Evaluate the proposed technique	**4- 5 Months**
7	Presentation of results in the form of research papers and thesis report.	**5- 6 Months**

TIMELINE DIAGRAM FOR THE ABOVE PROPOSED PLAN



7. Tools and Techniques Used

We will choose suitable tools available in the market according to our requirement. Lot of research is going on in the field of data mining to develop new tools and technologies at a very fast pace.

To carry out the proposed research the tools and technologies that may be used include:

1. PHQ-9 (Patient Healthcare Questionnaire) Instrument, GAD-7 (General Anxiety Disorder) Questionnaire for data collection from patients
2. DSM-5 Diagnostic and Statistical Manual of Mental Disorders -is the reference manual mental health professionals and physicians use to diagnose mental disorders
3. PCA- Principal Component Analysis- Extraction of suitable features.
4. WEKA 3.8.0- a machine learning platform
5. Graphical Tools- Smart Draw, MS-Excel
6. Testing Tools- K Fold Cross Validation

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